Kinetic Dialogues: Enhancing creativity in dance

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ABSTRACT

The paper describes an interaction between a human dancer and an improvising avatar, where the dancer gives kinetic feedback to the software in real time. By tracking the dancer's movements with a motion-capture camera and extracting basic motion features, the system detects feedback signals and lets them guide the avatar's behaviour. High intensity of movement by the dancer encourages novel and expansive behaviour in the avatar. Despite the crudeness and simplicity of the proposed mechanism, the high degree of feedback in both directions is expected to yield unpredictable and complex results. In comparison with more controlled settings, the open-endedness and complexity of this kinetic "dialogue" is likely to increase the creative potential of the exchange between dancer and software.

Author Keywords

dance; movement; creativity; artificial intelligence; human-computer interaction

ACM Classification Keywords

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INTRODUCTION

Can computer technology aid and enhance creativity in dance? What is the nature of the interaction between dancers and computers today? How will this interaction develop in the next decades? In an age when computer technology has become ubiquitous, we are witnessing phenomena wholly resulting from unprecedented large-scale connectivity and generation of data. These include the possibility to measure and visualise body functions in real time, as well as tracking and analysis of individual and collective activity.

How do these new technologies transform our approach to creative processes in dance? This paper presents ongoing work in the interdisciplinary project *AI_am* which brings together artificial intelligence (AI) and dance to investigate the capabilities of AI in aiding or enhancing creativity in a dancer's movement decisions. Previous work in the project has resulted in a dancing avatar which improvises in real time and generates novel movements by analysing and extending recorded human motion. Movement ideas generated by the avatar have been found to be surprising and innovative and have been used as building blocks for improvisation and choreography.

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The aim of the current work is to extend the previous experiments that involved a graphical interface towards a full-body kinetic interaction between the avatar and a human dancer, thus enabling movement ideas and signals to be exchanged in both directions. It is expected that such an interaction will increase the creative potential of the human-AI relationship. This paper presents a first step in this direction by proposing an interaction where the AI interprets human movements as feedback signals guiding its improvisations. Instead of merely observing the avatar, the dancer can choose to interpret and embody the ideas generated by the AI. Her responses to the avatar's movements guides the AI much like a child is guided by its parent. Through a primitive form of kinetic perception and adaptation, the avatar is pushed towards "braver" or more "cautious" behaviour depending on the dancer's level of engagement.

The paper begins with a brief account of how computer technology has been used in dance over the past few decades. The author's specific approach to kinetic AI is then outlined, and initial experiments where the software is used as a creative tool are reported. The concept of a "kinetic dialogue" between software and dancer is then presented. Finally, some conclusions are drawn.

PREVIOUS WORK

In the area of dance and choreography, artists have been using computer technology in creation and performance since the 1960's. Merce Cunningham is widely regarded as the first to use computer software to choreograph. In collaboration with Simon Fraser University, the LifeForms software was developed and used to create *Trackers* (1992), the first of many of his works to be made in this way. The software enabled Cunningham to clearly conceptualise movement sequences in digital time and space, a kind of "visual idea generator" [7].

Cunningham continued to lead innovative use of technology in his creative process until his death at age 90. A few years before his passing, he collaborated with the Open Ended Group (OEG) in the development of the piece *Loops* (2001). This work integrated real-time motion capture, algorithmic visualisation and sound generation. Cunningham's hand movements were captured by motion sensors and the data generated was processed by an AI which autonomously determined the behaviour of the resulting visuals. The soundscape was also generated in a similar way, using recordings of Cunningham's voice. Another example of work integrating real-time motion tracking and AI-driven visuals is OEG's collaboration with the Trisha Brown Dance Company in *How long does the subject linger on the edge of the volume* (2005).

In addition to being applied in performance, AI has also been used as a choreographic tool. OEG together with choreographer Wayne McGregor and multi-disciplinary digital artist Nick Rothwell have developed the Choreographic Language

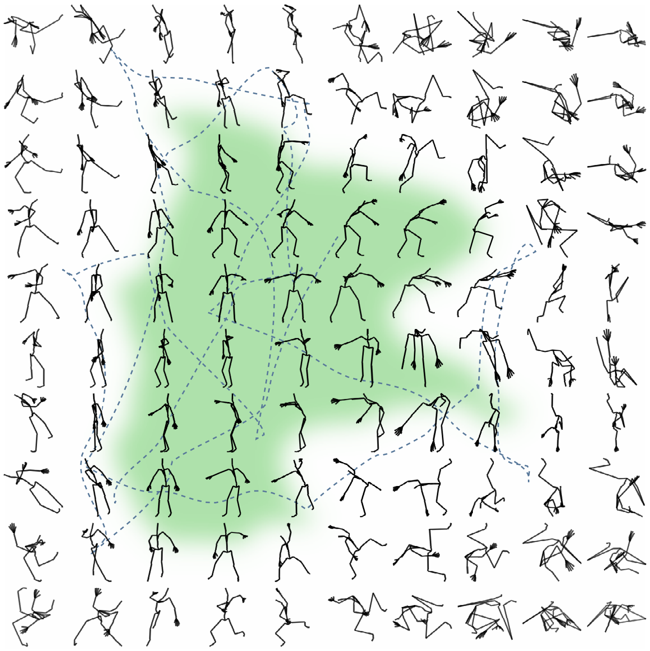

Figure 1. Example of a 2D pose map and a generated movement path. The green area represents the region of observed poses, while the surrounding areas contain poses without any equivalents in the training data. The blue dotted line represents an example of an automatically generated trajectory. In our actual experiments, a 7D map has been used.

Agent (CLA) which uses natural-language instructions directly related to McGregor's practice and interprets these into geometrical animations. The system has been used and developed in the studio with the company dancers and choreographer himself [4]. CLA was later modified as an abstract body and used as an "eleventh dancer" in the studio during the creation of McGregor's latest work *Atomos* (2013) [6].

Scuddle is another example of computer-aided choreography [3]. It generates incomplete movement material as catalysts for human dancers to interpret and embody.

The examples above illustrate how dancers and choreographers use software as choreographic tools for enhanced creativity. The work presented here positions itself in the same tradition. In contrast to previous work, our approach centres around an improvising, humanoid AI, acting as a virtual dance companion. In the same vein, McCormick et al. [5] describe a dancing AI which learns movements from its human partner. However, their AI is designed for movement recognition rather than creative elaboration.

POSE MAPS

Our approach to kinetic AI builds upon a technique for generating novel movements by analysing and extending movements captured from a human dancer [1]. The method can be summarised as follows. First, a corpus of human movements is recorded and stored as vectors containing orientation data for each joint, represented by unit quaternions. The complexity of the motion data is reduced by non-linear principal component analysis (KPCA) [8], yielding a "map" of poses. This map contains regions of observed as well as unfamiliar poses (see figure 1).

An improvisation algorithm is then employed to explore the pose map, generating pathways between and around observed poses. These trajectories across the map can be synthesised as full movements by sequencing the constitutive poses denoted by the path. The improvisation algorithm was designed so that it would primarily generate paths in the vicinity of observed poses, thereby producing somewhat realistic and familiar output. On the other hand, it should also expose novel poses beyond observed territories. The requirements were satisfied by an algorithm based on randomness, attraction to observed poses (familiarity) and deviation from observed poses (novelty):

1. Select a random observed pose in the map as the departure point p
2. Generate a set of destination candidates $\{q_i\}$, where each candidate is a random observed pose plus a random vector of magnitude N (the "novelty" parameter)
3. Choose the destination q as the candidate among $\{q_i\}$ whose distance to p has the smallest difference from the preferred distance E (the "extension" parameter)
4. Choose some intermediate points between p and q, where each intermediate point lies between a point on the straight line between p and q and its nearest observation in the map (closer to the nearest observation for lower N values)
5. Smooth the resulting path using spline interpolation
6. Create the next trajectory by treating the current destination as a departure and repeating steps 2-5

Our current experiments utilise a small database of movements which were choreographed and performed by the team's dancer. The database was reduced to a pose map of 7 dimensions, a value constituting a reasonable trade-off between simplification and accuracy.

KINETIC AI AS A CREATIVE TOOL

A software was developed based on the kinetic AI and assessed by the team's dancer for its usefulness as a creative tool. She is primarily specialised in modern dance and improvisation techniques as well as being a budding dance-maker. Her evaluation of the software was based on her own subjective analysis and recorded through note-taking and video recording.

When first introduced to the software, the dancer was immediately surprised by the exponential increase in the diversity of the avatar's movements. She was fascinated by their complexity and novelty in comparison to those she had choreographed for the dataset. The dancer's feedback indicated that the avatar's movements aroused inspiration not only to respond with movement but also to embody them.

The software featured a graphical interface with adjustable parameters for novelty, extension and speed, through which different combinations of settings were evaluated and experimented with in the dance studio. Strategies for improvisation and choreography utilising the software were developed. These included first using the avatar's movement as visual stimulus which evoked a movement response by the dancer. Then the visual was taken away and the dancer moved from the recalled sensation of witnessing and responding to the avatar. Another strategy was to use the avatar as a choreographer, with the software settings set to minimum novelty and extension to ensure the human feasibility of its movements. The dancer learnt phrases directly from the avatar and then experimented with them as choreographic material. The assessment resulted in motifs and phrases that the dancer indicated could be performed already as structured improvisation or further developed choreographically.

The kinetic AI was approached as a way to stimulate new ways of moving, and thus overcoming habitual movement decisions and clichés that plague creativity in dance. The movement demonstrated by the avatar had a weird grace, punctuated by a glitchy flow. Its way of moving greatly deviated from typical human ways which are usually confined to their genre or style of dance training.

Exposure to the kinetic AI not only allows the dancer to broaden the quality of movements, but leads her to the notion of exploring conceptual space. If in dance conceptual space can be thought of as the full spectrum of all possible dance movements, then the exploration of that space would yield movements never seen before. According to Boden, this exploration has creative value because it encourages the dancer to think differently about what limits and potential exists in the new way of approaching movement [2]. Therefore it can be said that the kinetic AI enhances the creative potential of the dancer.

KINETIC DIALOGUES

Our current work extends the previous experiments by enabling the dancer to interact with the avatar using her own movements instead of a graphical interface. The movements are captured using a simple motion camera such as Kinect, which has limited accuracy in terms of detailed movement, but allows basic motion features to be extracted. The upper limbs and centre of mass are tracked, providing the AI with a basic form of kinetic perception comparable to that of an infant. This method allows the AI to estimate the dancer's movement speed and degree of activity. The avatar uses this as feedback to guide its behaviour. Higher intensity of movement by the dancer encourages novel and expansive movement in the avatar that can be described as "brave behaviour". The lower the intensity of the dancer's movements, the more restricted the avatar's movements, resulting in "cautious behaviour". In this basic sense, more intense activity by the human dancer constitutes positive feedback for the AI.

The interaction strategy assumes a correlation between high estimated kinetic activity and positive appreciation of displayed movement. Naturally, this assumption is very crude and does not always hold. Furthermore, the AI does not "segment" observed movements into chunks, and the kinetic "proto-language" employed by the avatar lacks semantics or turn-taking. The aim of the experiment is not to simulate complex human cognitive processes but to enable an intuitive, immersive environment through with physical and digital forms interact in a way which stimulates kinetic creativity.

At the current stage of progress, the technical implementation is still ongoing and the interaction concept remains to be evaluated. Nevertheless, some preliminary reflections can be made. The increased degree of interactivity and kinetic immersion is likely to yield outcomes that would not emerge with merely a graphical user interface. The avatar's attention to the human dancer may encourage her to explore and discover new ways of moving. Furthermore, the tight coupling between the participants' behaviours may lead to interestingly unpredictable outcomes. For example, if the dancer imitates or extends the avatar's movements, her expressiveness and other aspects of her movement will influence the avatar's subsequent output, resulting in a feedback loop. The complexity of the interaction makes the outcome difficult to predict and will be interesting to study.

Future versions of the system could allow the AI to associate feedback signals to specific movement tendencies correlating to regions of its pose map. Through this reinforcement mechanism, the AI's assumptions about useful pose regions will be modified by the human input. More sophisticated and precise motion tracking technology could also enable the system to learn new poses from the dancer in real time, by allowing the pose map to be continuously updated. These forms of interactive learning will strengthen the human dancer's ability to "shape" the avatar's behaviour, while still leaving place for unexpected outcomes.

CONCLUSIONS

Technology has been given an increasingly important role in dance and choreography in the last decades, ranging from onstage interactions to computer-aided choreography and automated generation of movement ideas. This paper has focused on AI as a tool for creativity enhancement and has presented a concept for an interaction where a human dancer guides an improvising avatar by providing kinetic feedback in real time. It is expected that the mutual exchange of movement signals and the presence of feedback mechanisms will yield interesting outcomes that would not emerge in a more controlled setting.

On the surface, the proposed mode of interaction shares many similarities with dance improvisations between humans. However, the AI's ability to adapt and learn is very limited. For example, the system's underlying movement repertoire remains fixed throughout the interaction, since the pose map is based on pre-recorded movements. Furthermore, the feedback from the dancer only guides general aspects of the AI's behaviour, and cannot be used to shape its movements in more detail. These limitations can be addressed in future work.

The presented work merely constitutes a first step towards a more reciprocal exchange of movement ideas between software and humans. Nevertheless, we believe that these tentative "dialogues" will stimulate the dancer's kinetic imagination significantly. In a broader perspective, the work contributes to the ongoing discussion about how intelligent software can challenge and advance the fields of dance and choreography.

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